ROTARY WING ENGINEERING, MODELING, AND SIMULATION

STATEMENT OF WORK

This Statement of Work (SOW) describes the requirements for contract services for aeronautical rotary wing engineering, research and development, systems analysis and modeling and simulation.

1.0 Background

NASA pioneers the advancement of knowledge and innovative technology in subsonic rotary wing disciplines, rotorcraft aeromechanics and human-system integration. NASA conducts this research and development through many approaches, including the following.

- Conducts fundamental and applied research to improve rotorcraft performance in the areas of aerodynamics, dynamics, flight controls and handling qualities, flight testing, simulation, acoustics, comprehensive analysis and advanced design
- Develops the associated technology and transfer the results and tools to the U.S. aerospace community
- Develops new technologies for application to civilian helicopters, tilt rotor aircraft, and other advanced rotary-wing aircraft
- Provides the U.S. rotorcraft industry, Department of Defense, and other Government agencies with the technical expertise required to produce and use safe, affordable, and effective all-weather rotorcraft systems
- Conceives, develops, evaluates, and tests the procedures, processes, and actions for using manned and unmanned rotary wing vehicles, in conjunction with other aircraft, in the national airspace system and proposed next generation airspace systems from the perspective of the pilot/operator, his/her interface, the passenger, and the ground controller interface and airspace infrastructure

The intent of this solicitation is to procure the needed skill, capabilities, goods and services to enable these efforts.

2.0 Use of Unique Research Facilities

The services performed under this contract may require the use of various research facilities including but not limited to the following:

- Vertical Motion Simulator (VMS) at Ames Research Center
- National Full-scale Aerodynamics Complex (NFAC)
- Rotorcraft Aircrew Systems Concept Airborne Laboratory
- High End Computing Columbia Project

This solicitation does not preclude the possibility that facilities may be provided that are located at other NASA Centers or other federal laboratories.

3.0 Scope of Work

This Statement of Work describes technical services required to fulfill the technology development needs to meet NASA's R&D mission. These services fall into the following broad categories:

- Rotary wing aeromechanics modeling and analysis
- Simulation facility hardware and software development for experimental research and feasibility assessments
- Aircraft performance, handling qualities, cockpit displays, and flight control systems analysis and evaluation
- Distributed and non-distributed models and simulation information technology
- Human-in-the-loop simulation research and development, test and evaluation, and training

- Mission effectiveness analysis, modeling and simulation, and program analysis and management
- Air traffic management development and assessment of new operating procedures and interfaces

The Government will issue Task Orders (TOs) to define the services through task order statements of work that include deliverables and period of performance for each task. All work shall require a TO approved by the Contracting Officer, and this shall constitute the normal basis for work accomplishment and performance assessment. Each TO will reference the applicable Section of this SOW and will define milestones, deliverables, applicable documents, reporting requirements, Government Furnished Equipment, and travel requirements. TOs will be performance based; that is, they will be written in terms of expected outcomes that can be objectively measured by the government.

The Government reserves the right to increase or decrease the level of contractor services (including adding/revising requirements) in any of the identified areas or to add contractor services to other programs and facilities. Any such increases or decreases will be accomplished via a supplemental agreement.

4.0 Description of Required Services

The requirements of this SOW are organized into six Performance Areas:

(1) Rotorcraft Aeromechanics Modeling and Analysis

(2) Simulation Facility Hardware and Software Development for Experimental Research and Feasibility Assessments

(3) Aircraft Performance, Handling Qualities, Cockpit Displays, and Flight Control Systems Analysis and Evaluation

(4) Distributed and Non-Distributed Models and Simulation Information Technology Services

(5) Human-in-the-Loop Simulation Research and Development, Test and Evaluation, and Training

(6) Operations Effectiveness Analysis, Modeling and Simulation, and Program Analysis and Management

Within this SOW, descriptions of services may include bulleted lists. These lists are intended to describe some of the major activities within the service being described and should not be considered complete or comprehensive.

In order to meet the Government's objectives, the Contractor may, at times, be required to provide all or any portion of these services twenty-four hours a day, including weekends and holidays. In addition, these services may be provided to other NASA facilities, installations, or other Government Agencies.

4.1 Rotorcraft Aeromechanics Modeling and Analysis

4.1.1. Aeromechanics Simulation Model Development

The contractor shall develop comprehensive aeromechanics models for engineering analysis. Aeromechanics is the multidisciplinary discipline of helicopter analysis which embraces aerodynamics, dynamics, structural dynamics, loads, acoustics, aeroacoustics, and controls for vehicle flight as well as controls to enhance aeromechanical behavior. The contractor shall provide flight dynamics models of varying complexity as required to support the mission, from high fidelity real-time models for piloted engineering evaluations to simplified real-time models for pilot training and computer generated forces. The sophistication of these models will be tuned to match the application, and the computational intensity will be geared to the available computer equipment. In addition, the Contractor shall document the traceability of all simplified models to a primary engineering level model to insure appropriate fidelity at all levels.

4.1.2 Simulation Services to Support Flight Testing

The contractor shall perform automated flight test simulation services to support flight tests. These services shall include, but are not limited to:

- Assisting in flight test plan development, data acquisition strategies, data acquisition and reduction, and analysis
- Generating standard plot formats
- Performing sensitivity analyses on sensor locations and control input frequency content

- Conducting real-time simulation for test pilot familiarization
- Conducting on-line simulation during flight testing to enhance flight safety and support real-time planning and evaluation
- Utilizing simulated flight tests to augment actual flight testing

4.1.3 Aeromechanics Model Validation

The contractor shall perform services to validate aeromechanics models and simulations. These services shall include, but are not limited to:

- Preparation and processing of flight test data for use in validation
- Performing simulated flight tests and comparing the results of these tests with actual flight test results
- Processing of flight test data to enable further modeling and simulation prediction of radiated far field acoustics
- Upgrading model structure (structure validation) and model parameters (data validation) to improve correlation between flight test and simulation
- Validation of interference models

4.1.4 Aeromechanics Model Design Analysis

The contractor shall perform services to evaluate the design of aeromechanics models in terms of performance, stability, handling qualities, and other parameters. These services shall include, but are not limited to:

- Generating performance tests and assessing design tradeoffs
- Extracting linearized models and evaluating stability and controllability information
- Performing automated handling qualities evaluations in accordance with Aeronautical Design Standard 33, *Handling Qualities Requirements for Military Rotorcraft in Degraded Visual Environments*
- Predicting steady and vibratory loads
- Predicting acoustic footprints to optimize mission trajectories; altering design features to achieve acoustic requirements if required
- Predicting interference effects of main rotor, fuselage, and two-dimensional control surfaces on each other

4.1.5 Integration of Aeromechanics Simulation Models into Distributed Simulation Environments

The contractor shall provide services to integrate aeromechanics simulation models into distributed simulation environments. These services shall include, but are not limited to:

- The simulation of vehicles (including UAVs) to include strategic displays, navigation and communications equipment, radar sensors, weapon systems and countermeasures, and the modeling of the interaction between these systems, mother ship flight dynamics, and the air traffic management system
- Integration of high quality flight dynamics models with a high fidelity cockpit using a flexible application programming interface
- Integration of simplified flight dynamics models with behavioral modeling systems assigned to vehicles to provide realistic aviation computer generated forces
- Integration of flight dynamics models with a distributed interactive simulation interface in a multi-vehicle simulation and the establishment of a format for instancing the simulation in a specific scenario
- Integration of aeromechanics models with actual (real-world) flight control computers, control actuators, and digital databases

4.1.6 Training in Aeromechanics Modeling, Design, and Analysis

The contractor shall provide services to train users in the capabilities and limitations of specified aeromechanics models. These services shall include, but are not limited to:

- Self guiding tutorials in the use of aeromechanics simulations for design, evaluation, and testing, with examples that can be performed by those with access to simulations
- Formal classroom training which may include real world and on-line simulation examples

4.2 Simulation Facility Hardware and Software Development for Experimental Research and Feasibility Assessments

4.2.1 Simulation Scenario Design and Development

The contractor shall provide services to design and develop scenarios for mission simulation exercises. Scenarios shall portray realistic situations/conflicts in terms of fidelity of behaviors, scale of conflict, type of conflict, number of participants/combatants, types of participants/combatants, and other features. Behaviors of systems included in the scenarios shall conform to accepted/approved concepts of operation. Other systems shall be consistent with U. S. government data and expectations regarding performance capabilities and concepts of operation. The contractor shall also prepare dialogue and event scripts to augment each scenario.

4.2.2 Government Simulation Demonstration and Exercise Coordination

The contractor shall provide services to coordinate GFE models and simulations with Government multi-participant simulation demonstrations and simulation. The contractor shall identify facility and test requirements. The contractor shall establish procedures and guidelines to ensure compliance with demonstration/exercise objectives and compatibility of GFE models and simulations with the overall simulation environment and other participants.

4.2.3 Independent Industry Project Assessments

The contractor shall provide services for independent assessment of government projects. Assessments shall include planning and coordinating project briefings, summarizing private industry contributions and preparing a written review and critique to the government. The contractor shall arrange the participation of industry representatives and shall furnish the services, facilities, equipment, and materials necessary to conduct the review and critique.

4.2.4 Simulator System Development and Operation

The contractor shall provide services to develop simulator systems, assess system potentials for meeting present and future Department of Defense research and development simulation requirements, and provide overall detailed system analysis to ensure optimum design to meet user requirements. These services shall include, but are not limited to:

- Engineering and psychophysical evaluations
- Software and hardware development
- System refinements and upgrades
- System safety support
- Man-rating support
- Airworthiness assurance support
- Documentation for prototype technology demonstrations and delivered systems

The Contractor shall provide services for simulator operations and maintenance. These services shall include, but are not limited to:

- Assuring sufficient on-site maintenance services to expeditiously correct system malfunctions
- Conducting off-line diagnostics and repairs
- Procuring and maintaining an adequate supply of spare parts to maintain the operational integrity of the entire system

4.3 Aircraft Performance, Handling Qualities, Cockpit Displays, and Flight Control Systems Analysis and Evaluation

4.3.1 Handling Qualities Evaluations and Criteria Development

The contractor shall provide services to evaluate the handling qualities of fixed and rotary wing aircraft. The contractor shall also provide services to conduct or assist in the conduct of piloted simulations and flight tests to assess aircraft handling qualities. The contractor shall develop or modify handling qualities criteria as necessary to account for factors that are not included in existing criteria.

4.3.2 Flight Control System Design and/or Evaluation

The contractor shall provide services to evaluate and design control laws for new aircraft flight control systems and upgrades to existing systems. These services shall include, but are not limited to:

- Evaluation of and recommendation of improvement to developmental flight control systems

- Development and validation of modifications to existing flight control systems
- Conduct of basic research on flight control systems

4.3.3 Design of Display Symbology and Control Laws

The contractor shall provide services to design displays and controls for fixed and rotary wing aircraft. These services shall include, but are not limited to:

- Development of a methodology to quantify the impact of degraded visual cueing on rotorcraft handling qualities
- Development and evaluation of controls and displays for steep approaches in conditions of very low visibility
- Development and evaluation of symbology, raster displays, and control laws for heads-up displays (HUD), or helmet mounted displays (HMD) to assist in fixed-wing landings in conditions of very low visibility

4.3.4 Piloted Simulation for Evaluation of Displays and/or Handling Qualities

The contractor shall provide services to support the development and conduct of piloted simulations. These services shall include, but are not limited to:

- Development and checkout of the simulation code
- Preparation and execution of test plans
- Interpretation of the results from simulation handling qualities experiments

4.3.5 Flight Testing for Evaluation of Displays and Handling Qualities

The contractor shall provide engineering and test pilot services for fixed and rotary wing flight test programs related to the evaluation of controls, displays, and handling qualities.

4.4 Distributed and Non-Distributed Models and Simulation Information Technology Services

The contractor shall provide services to apply Information Technology principles to the analysis, use, and application of models and simulations in all phases of the software development processes. These services will encompass, among others, the application of high fidelity models and simulations library components to enhance advanced rotorcraft simulations, and the development and application of Verification and Validation (V&V) policies, procedures, and methodologies for aged monolithic models and simulations and distributed simulation systems. Under this task, the contractor will provide a staff of simulation analysts, and simulation, software, and satellite navigation engineering subject matter experts that can apply their expertise to aid the Government in the design, development, and V&V of advanced rotorcraft simulations, including real-time, high-fidelity, human-in-the-loop simulations for piloted operational assessments of future aircraft concepts. This expertise shall include experience in the design, implementation, and testing of navigation, surveillance, guidance and control, communications, and subsystems hardware and software, a novel approach to the V&V of complex legacy and developing simulation software that incorporates the use of automated tools, and hands-on experience in prototype V&V activities for distributed interactive simulations.

4.4.1 Development, Implementation and Application of Modeling and Simulation Software Modules and Techniques

The contractor shall provide services to develop and apply engineering level (high fidelity), platform (high fidelity), and mission/campaign (typically lower fidelity) simulations based on an internal model and simulation library. These simulations will be used to assess the combat effectiveness of future aircraft designs in operations, pilot training, and mission planning.

4.4.2 Development and Implementation of Verification, Validation and Accreditation Plans, Policies, Procedures, and Methodologies

The contractor shall provide services to develop and implement Verification, Validation and Accreditation (VV&A) policies, procedures, and methodologies to ensure that models and simulations comply with Government standards and regulations. These services shall apply to VV&A policies, procedures, and methodologies for: 1) monolithic or standalone models and simulations, and 2) distributed systems, to include distributed simulation, Advanced Distributed Simulation (ADS), and High Level Architecture (HLA) applications. The contractor shall conduct planning, execution, and analysis of VV&A. These activities shall encompass the VV&A of legacy and

developmental monolithic models and simulations as well as the VV&A of distributed simulation, ADS, and HLA design applications.

4.4.3 Modeling and Simulation Development

The contractor shall provide Modeling and Simulation development services. These services shall include, but are not limited to:

- Development of preliminary design goals and requirements
- Development of engineering level designs
- Development (coding) and modification of software
- Test and evaluation
- Preparation and review of documentation

Additional development activities include providing comparison analyses between similar classes of models and simulations and the evaluation of existing models and simulations to meet specified requirements. The contractor shall also maintain an awareness of the status of Modeling and Simulation within the Government and shall incorporate emerging strategies and trends into their software development practices.

4.4.4 Prototype Tool Development and Evaluation

The contractor shall provide services to survey and evaluate modeling and simulation tools. The contractor shall survey commercial off-the-shelf automated tools to determine their applicability to software development and V&V, and incorporate suitable tools into the simulation development environment. If no tools are found with the required functionality, the contractor shall develop new tools or augment existing ones.

4.4.5 Radio Frequency Safety Assurance Services

The contractor shall provide technical services to the in the area of radio frequency (RF) emission evaluation and shall advise the Government of the safety levels associated with the site. These services shall include, but are not limited to:

- Making field measurements and evaluations of RF emitters, providing expert guidance on how to investigate and resolve RF safety inquiries, providing expert testimony, and preparing documentation of all field surveys
- Maintaining an RF overexposure repository, including updating the repository with new cases and providing both summary reports and data retrieval
- Providing advice in response to specific technical/safety questions from field units regarding safe use of specific RF systems at their locations, facilitating and transferring field information and concerns to Government research personnel and new research information to field units, and maintaining a log to document all telephonic RF safety consultation

4.4.6 Simulation Based Acquisition Services

The contractor shall provide services to support Simulation Based Acquisition (SBA) efforts and initiatives. These services shall include, but are not limited to:

- Development of concepts, requirements, design of support architectures, and the design and development of models and simulations that fit within the architecture
- Compilation of relevant SBA-type models and associated tools that can be applied to the conceptual acquisition phases of relevant programs
- Definition of a virtual model of a generic SBA project. Design tailoring of the architecture for the SBA complying with applicable protocols and standards from Test and Training Enabling Architecture and HLA
- Development of a distributed architecture for integrated product and process development (IPPD) that can be used throughout the total life cycle of a system
- Demonstration of a conceptual architecture of the prototype Simulation Based Acquisition and Live Training tool

4.5 Human-In-The-Loop Simulation Research and Development, Test and Evaluation, and Training

4.5.1 Human-in-the-Loop Simulation Studies for Research and Development, and Test and Evaluation

The contractor shall provide services to develop designs for experiments on rotorcraft mission effectiveness ranging from analytical studies through part-task simulation to full-mission simulation. These experiments are expected to

entail the use of flight simulators for both research on and training of pilot subjects and to require both traditional and innovative experimental design in applied behavioral research. These services shall include, but are not limited to:

- Definition of experimental objectives
- Design of experiments in accordance with accepted scientific methods
- Development of test plans for data collection, reduction, and analysis

4.5.2 Training, Training Programs, and Training Systems to Support Pilot-in-the-Loop Simulation Studies

The contractor shall provide services to develop training programs and training systems serving pilots, subject matter experts, and support personnel. The training will cover such topics as the operation of simulator controls and displays, the operation of auxiliary team stations, and the roles to be played by the support personnel in emulating full mission scenarios. The contractor shall provide the full spectrum of training activities, including:

- Training of simulation subjects
- Scheduling of training activities and data collection intervals
- Introductory lecture sessions
- Controls and displays training using the training stations
- In-simulator training

4.5.3 Development of Data Analysis Procedures and Performance and Effectiveness Measures

The contractor shall provide services to develop procedures for achieving rapid production of summaries and analyses of data collected during simulation experiments. These services shall include, but are not limited to:

- Specification of performance measurement data summary and analysis requirements in terms of formats, extraction sets, configurations, and time base as part of a pre-run file
- Formalization and extension of the post-run quick look data production
- Validity and integrity checking of the raw data collected
- Automation of the Relational Database populating procedures
- Automation of batch processing of data extraction, summarization, and analysis configuration processes
- Automation of the procedures for producing tabular and graphic data summaries as well as preliminary analyses such as Analysis of Variance and Multivariate Analysis of Variance
- Development procedures for rapid manual entry of data into the database

The contractor shall develop procedures for checking data integrity, automating the database population, data extraction, and data summary and analysis.

4.5.4 Development of Advanced Performance Measurement Techniques

The contractor shall provide services to develop performance measurement methodologies including Measures of Effectiveness that can be used to assess multi-faceted operator/crew/controller behavior in full-mission simulations and other complex environments such as field tests.

4.5.5 Research System Integration

The contractor shall provide services to coordinate research project goals and necessary simulator modifications. The contractor shall communicate with the Government research manager regarding project requirements, and to assist the project leader in obtaining and communicating accurate information to operations personnel in a timely fashion.

4.5.6 Human Factors Engineering

The contractor shall provide specialized human factors engineering services to support interface development, systems engineering, and testing of emerging mission-dependent technologies. These services will be applied to human-system design, operator/crew/controller mission performance measurement, and constructive and virtual simulation for acquisition decision support and evaluation of equipment, systems and procedures. These services shall include, but are not limited to:

- Context characterization and design; research, test and evaluation; and the development of simulation methodologies applying cognitive and behavioral task analysis, workload assessment and situation awareness assessment, and design of decision and situation awareness support systems

- The development and application of performance measurement techniques at the mission, function and task levels based on a full spectrum of objective data, video records, and observational judgments and subjective measurements
- The analysis of data using a variety of inferential statistical methods
- Preparation of conventional and multimedia reports with text, graphics, video and sound, to summarize and highlight the salient features of the research and testing outcomes
- Refinement and improvement of constructive and virtual simulation methodologies
- Preparation of quantitative descriptions of human cognitive and behavioral characteristics including latencies, durations, variabilities, accuracies, and errors suitable for use in constructive simulation and modeling of semi-automated forces as well as to support the verification and validation processes
- Enhancement of evaluation methodologies by analyzing and documenting the functional differences between complex mission-dependent systems, characterizing the impact of the differences on simulation development, system usability, and mission accomplishment

4.6 Operations Effectiveness Analysis, Modeling and Simulation, Program Analysis and Management

4.6.1 Operations Analysis

The contractor shall provide subject-matter-expert and consulting services concerning current and projected tactical and operational operations. Consulting services shall include informal and formal briefings detailing the employment of current and projected forces and systems in individual, combined, joint, and coalition operations in accordance with current and projected doctrine and tactics, techniques, and procedures.

4.6.2 Modeling and Simulation Support

The contractor shall provide services to evaluate simulation models under consideration for Government use. These evaluations shall include, but are not limited to, the areas of model fidelity, realistic player behavior, environmental effects, player component behavior, flexibility, compatibility with other models in a distributed simulation environment, and model-user interface issues. The contractor shall provide services to develop new simulation models and to modify existing models. Specific areas to be covered include developing appropriate characteristics and performance of aircraft and other systems types, defining the attributes of their systems and subsystems, representing effects of the tactical environment, representing realistic operational and tactical behaviors, defining user interfaces, and structuring and populating data input libraries.

4.6.3 Requirements Analysis

The contractor shall provide services to develop a requirements analysis process capable of defining functional level requirements for use in generating design specifications for both hardware and software. The contractor shall document the results in a format and a level of detail sufficient to develop system level hardware and software designs. The contractor shall provide services to develop a methodology for defining Measures of Effectiveness and Measures of Performance to support the requirements analysis process.

4.6.4 Development, Implementation and Management of Simulation Training Programs to Support Government Simulations

The contractor shall provide services to develop, implement, and manage training programs to support simulation demonstrations, experiments, operational tests, studies, and technical tests using constructive, virtual, and live simulation. These services shall include, but are not limited to:

- Reviewing objectives of demonstrations, experiments, and tests to determine training needs
- Identifying the type of training to be accomplished
- Determining schedules, resource requirements, and allocations
- Creating lesson plans and training objectives
- Executing and managing training programs

4.6.5 Scenario Generation

The contractor shall provide services to develop realistic tactical and operational scenarios. The scenarios shall include, but are not limited to:

- Participant orders of placement, and movement

- Specific vehicle and subsystem models with realistic characteristics, capabilities, and behaviors
- Terrain, environmental factors, and illumination to support scenario objectives
- Operations orders, maps, and other planning products
- Scenario timelines and scripting

4.6.6 Simulation Support Services

The contractor shall provide subject-matter-expertise for programs dealing with advanced civilian and/or military aircraft analysis, design, conceptualization, employment, application of advanced technologies, and simulation demonstrations, experiments, operational tests, studies, and technical tests using subject matter experts together with constructive, virtual, and real and/or non-real time simulation. These services shall include, but are not limited to:

- Reviewing program modeling and simulation objectives and making assessment on technical readiness and risk minimization to meet program goals, schedules, and budgets.
- Analyzing the application of advanced technologies for maximum benefits
- Developing training scenarios to highlight the capabilities of the assets on hand

4.6.7 Operational Requirements Analyses

The contractor shall provide services to perform operational requirements analyses. These services shall include, but are not limited to:

- Identifying pertinent references and sources related to operational and tactical issues
- Selecting and evaluating analytical tools for application suitability
- Performing analyses effectively to obtain results to desired degree of certainty
- Documenting final results including references, sources, and assumptions
- Translating operational requirements into terminology easily understood by engineers and scientists

4.6.8 Program Management

The contractor shall provide services to plan, execute, evaluate, and report research and development projects. These services shall include, but are not limited to:

- Planning, scheduling, cost estimation, budgeting, and resource allocation
- Establishing program-specific schedule and cost metrics and control measures

4.6.9 Development of Specifications and Standards

The contractor shall provide services to assist Government personnel in preparing and assessing Government Standards in technical areas such as cockpit controls, cockpit displays, remote operators, and airspace operators for manned and unmanned systems.

5.0 Abbreviations and Acronyms

ADS	Advanced Distributed Simulation
AHB	Ames Handbook
AMM	Ames Management Manual
AMSIM	Advanced Modeling and Simulation Facility
APEX	Advanced Prototyping, Engineering and eXperimentation Laboratory
APMS	Ames Power Management System
ARC	Ames Research Center
AMRDEC	Aviation and Missile Research and Development Engineering Center
CO	Contracting Officer
COTR	Contracting Officer's Technical Representative
DO	Delivery Order
DoD	Department of Defense
FAR	Federal Acquisition Regulation
GFP	Government Furnished Property
HLA	High Level Architecture
HMD	Helmet Mounted Display
HUD	Heads-Up Display
IPPD	Integrated Product and Process Development
MIDAS	Man-Machine Integration Design and Analysis System
NASA	National Aeronautics and Space Administration
NFAC	National Full-Scale Aerodynamics Complex
NEMS	NASA Equipment Management System
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
RF	Radio Frequency
SBA	Simulation Based Acquisition
SOP	Standard Operating Procedure
SOW	Statement of Work
V&V	Verification and Validation
VMS	Vertical Motion Simulator
VV&A	Verification, Validation and Accreditation